Vol. VII. *November, 1904.* *No. 6*

BIOLOGICAL BULLETIN

FORM-REGULATION IN CERIANTHUS, VII.

Tentacle-Reduction and Other Experiments.

C. M. CHILD.

Experiments on Cerianthus Membranaceus.

In the preceding papers certain experiments upon *C. membranaceus* have been mentioned from time to time. It was impossible on account of lack of material to make my studies of this species as full and complete as those of *C. solitarius*. The data obtained were sufficient, however, to show a close correspondence between the two species as regards regulative phenomena.

It was possible to delay tentacle-regeneration by preventing the establishment of internal water-pressure by the methods employed for *C. solitarius*, viz., by reopening at short intervals or by giving the pieces a form such that closure was delayed or prevented.

It is not necessary to give the data of the experiments in full since they add nothing essential to the facts already given for *C. solitarius*. A few points are, however, of some interest especially in view of certain experiments which Loeb performed on this species.

In consequence of the greater thickness and stiffness of the body-wall in this species as compared with *C. solitarius* it is much less difficult to obtain pieces in which the enteron remains more or less widely open for a considerable length of time, in some cases indefinitely. In such pieces tentacle-regeneration is greatly delayed but sooner or later some regeneration does occur.

Loeb ('91, pp. 44 and 45, Figs. 4–6) describes briefly and figures cases of this kind which he obtained by cutting rectangular pieces from one side of the body. His figures show that regeneration of the tentacles occurs but they also show that it is much delayed, since in his Fig. 6, the most advanced stage shown, the tentacles are only a few millimeters in length, although this piece is two months older than Fig. 4. A piece regenerating in the typical manner during more than two months should possess marginal tentacles 25–40 mm. in length.

Loeb's figures and text indicate that little attention was paid to the internal anatomy of the form. He states that in these rectangular pieces the number of tentacles regenerated was a fraction of the whole number possessed by the original animal corresponding to the fraction of the total circumference represented by the oral end of the rectangular piece, but no reference is made to the correspondence of the tentacles with the intermesenterial chambers. According to Loeb's statements and figures the tentacles appear to arise from the oral cut surface of the piece in each case, but according to my own observations they never arise in this manner. It is difficult to understand how hollow, tubular tentacles could arise directly from the cut edge of the body-wall. This point is of some importance, since if Loeb is correct the influence of internal pressure upon the regeneration of the tentacles becomes at least extremely doubtful.

In the first paper of this series ('03*a*) the typical course of regeneration in *C. solitarius* was described. It was shown there that the new tentacles do not arise at the cut surface but at some little distance from it. The margin of the body-wall rolls inward after section and the tentacles arise at the highest, most oral part of the rounded margin thus formed ('03*a*, Figs. 13–19).

In the specimens of *C. membranaceus* which I have observed the tentacles arise in exactly the same manner. The margin rolls inward and soon changes in the body-wall appear in a region several millimeters distant from the actual cut surface, viz., at the most oral region of the inrolled part. Thus an area extending about the whole circumference is established in which first loss of pigment and reduction in thickness of the body-wall occur, and then the new marginal tentacles appear as minute buds.

In the open pieces corresponding to Loeb's Figs. 4–6 the tentacles arise in exactly the same manner, though much more slowly than in closed pieces. The margin of the piece rolls inward and the new tentacles appear on a part of the body-wall which was originally somewhat aboral to the cut surface.

At first glance it may appear that the regeneration of tentacles in these pieces with open enteron cannot be influenced in any way by internal pressure, but a brief consideration of the matter will be sufficient, I think, to show that even in these pieces some degree of internal pressure is possible. It must be remembered first that the circulatory currents running orally in the intermesenterial chambers continue in pieces with open enteron, except where contraction may bring about the more or less complete obliteration of certain chambers by approximation of the mesenteries. These currents force the water orally into the inrolled region at the oral end. If now the exit of the water from this region be hindered in any way, some slight degree of distention may arise within this rolled portion. Repeated examination of pieces of this kind has led me to the conclusion that the inrolled edge usually presses against the free margins of the mesenteries with some force and may thus hinder in some degree the exit of water. The diagrams 1 and 2 will serve to illustrate this point. In these figures a longitudinal section of the oral end is shown, the cross-hatched portion representing the mesenteries. In Fig. 1 the inrolled edge of the body-wall is shown. Since these pieces represent only a part of the whole circumference of the body the inrolling at the oral end is usually greater than in a complete cylindrical piece, for in the latter the inrolling about the whole circumference soon results in mutual pressure between the various parts of the inrolled portion which prevents further inrolling.

Fig. 1.

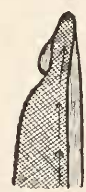

Fig. 2.

The result of the inrolling is to press the cut surface against the margins of the mesenteries. In the collapsed condition these folded and thickened margins form a dense mass and the inrolling of the cut edge upon this must press them still more closely together. In whatever spaces remain between the mesenteries the cilia force the water orally as indicated by the arrows in Figs. 1 and 2. The margins of the mesenteries, being more or less closely pressed together, do not readily permit the escape of the water and consequently a certain degree of pressure may be maintained. Diffusion of water through the walls in this region may also aid in maintaining pressure.

According to this view these cases are merely special cases of more or less complete local closure of the enteron by inrolling. Various experiments of similar kind have already been described (Child, '04*c*). The only difference between those and these is that here the inrolling is transverse across the oral end and consequently permits the appearance of tentacles upon the whole inrolled portion. Fig. 2 shows the condition of the end after the regeneration of tentacles has begun. By this time the mesenteries in the region of the inrolled margin have acquired new relations to the body-wall such that the margin is held in position. The reduction in thickness of the wall in the upper portion of the inrolled region represents the beginning of tentacle formation. In every case of this kind which I have observed conditions have been similar. The only conclusion possible is that Loeb's statement that the tentacles arise from the cut surface is incorrect and that in the pieces shown in his Figs. 4–6 the tentacles arose in the manner which I have described.

If my explanation is correct, then the results obtained from these open pieces do not contradict the conclusions of my previous papers, viz., that internal water-pressure constitutes a factor in tentacle-regeneration. As regards local pressure due to circulatory currents and its possible effects the statements made in previous papers (Child, '04*b*, '04*c*, '04*d*) will apply here.

In all pieces of this kind the appearance of the tentacles is much delayed and their regeneration is very slow. In no case observed do they ever attain more than a small fraction of the normal length. They are, moreover, always more or less blunt and frequently very irregular, *i. e.*, of different lengths. Similar characteristics were described and discussed for certain cases in *C. solitarius* in a previous paper (Child, 04*c*). Thus in *C. membranaceus* as in *C. solitarius* the facts indicate that internal pressure plays an important rôle in tentacle-regeneration.

The Reduction of Normal Tentacles.

Not only was it possible to retard or inhibit the regeneration of tentacles by reduction of the internal water-pressure, but it was found that fully developed tentacles could be reduced in length by reducing the internal pressure. This process of reduction comprises two distinct stages. During the first stage the collapsed tentacles gradually become shorter but do not change in appearance, except to become more and more deeply colored as the pigment-particles are more and more closely approximated with reduction in surface. This reduction continues during a month or more according to various conditions, *e. g.*, the completeness of collapse, the temperature, etc.

If, however, the condition of collapse be continued during a still longer period the tips of the tentacles began to atrophy, becoming darker in color and shrivelled or withered in appearance. This process of atrophy gradually extends proximally along the tentacle if the internal pressure is not reëstablished, until in some cases mere stumps of tentacles remain. The Figs. 3–5 show

FIG. 3.

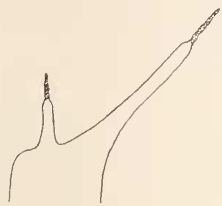

FIG. 4.

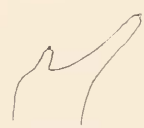

FIG. 5.

schematically the process of atrophy, one side of the disc with tentacles being shown in section in each figure. Fig. 3 represents a stage in which the marginal tentacles have been reduced by about one half their length and the labial tentacles relatively less. Figs. 4 and 5 represent later stages. In Fig. 5 the long shrivelled distal portion seen in Fig. 4 has been almost completely resorbed. The reduction in size of the disc in consequence of reduced pressure is also indicated in the figures. The difference in appearance between the healthy and shrivelled portions is always marked and visible at a glance. The tips are always much darker in color than the normal tentacle and are irregular in contour, so that the use of the term "shrivelled" is amply justified by their appearance. The proximal healthy portions are about equal in length in all the tentacles of each set, *i. e.*, the atrophy of the tips proceeds with equal rapidity in all tentacles of each set. The tips apparently always remain closed.

A gradual reduction in size of the shriveled portions, due to slow resorption, occurs, and these parts may disappear almost completely, leaving blunt, stump-like tentacles with only slight traces of the dark atrophied tissue at their tips (Fig. 5).

A few experimental data will serve to illustrate more fully this process of atrophy and the conditions under which it occurs.

Series 50.

November 21, 1902. — In three specimens of *C. solitarius* the aboral end was removed by a transverse cut (Fig. 6) and the aboral half of the distal piece was split longitudinally by several irregular cuts in order to render closure impossible or difficult. In these pieces the aboral end was reopened daily or on alternate days in the manner described in a previous paper (Child, '04*b*).

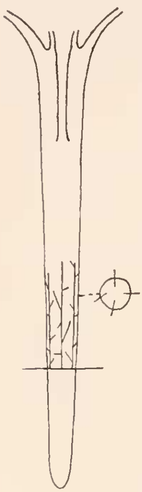

FIG. 6.

Controls were obtained by removing the aboral end from three specimens at the same level as in the experimental pieces. These controls were allowed to remain undisturbed and the cut ends closed in the usual manner. In all specimens, both experimental pieces and controls, the tentacles were measured in a fully distended condition before section. The marginal tentacles were 15–20 mm. in length, differing somewhat in different specimens; the labial tentacles were 5–7 mm.

December 17, 1902. — 26 days after section. Experimental pieces. Reopened daily on alternate days, but sometimes became more or less distended during the intervals, owing to approximation of the cut margins and plugging of the intervening spaces with slime. During this time the tentacles have gradually decreased in length. Marginal tentacles 6–8 mm.; labial tentacles 3 mm.

Controls. The tentacles remained collapsed for a day or two after section, then, as closure of the ends proceeded, the internal water pressure was established and the tentacles became distended. The length of the tentacles is about the same as before section, viz., marginal tentacles 15–20 mm.; labial tentacles 5–7 mm.

From this time on the three experimental pieces were left undisturbed in order to determine whether, after closure of their aboral ends and distension, the tentacles would regain their original length.

December 28. — 37 days after section. Experimental pieces. All healed aborally and fully distended with water. During the eleven days since December 17 the tentacles gradually elongated. In the three pieces the lengths of the tentacles were as follows: marginal tentacles, 12–15 mm., 11–12 mm., 10 mm.; labial tentacles, 5 mm., 4 mm., 3–4 mm.

The longest tentacles at this time belong to the piece which originally possessed the longest tentacles, viz., marginal, 20 mm., labial, 7 mm.

Controls. — In no case do the tentacles show any appreciable reduction in length.

No further increase in length of the tentacles of the experimental pieces occurred.

During the first 26 days the marginal tentacles of the experimental pieces decreased more than 50 per cent. They were more or less completely collapsed during this period, and as a collapsed tentacle is always shorter than one that is distended, it may appear at first glance that the reduction in length represents merely this difference. This, however, is not the case. During the first few days following section the collapsed tentacles were only slightly shorter than they had been when distended and a continuous gradual reduction in length took place up to December 17. During the following period of eleven days in which closure and renewed distension occurred, the tentacles elongated gradually. If the reduction in length had represented only the difference between a collapsed and a distended tentacle it might be expected that the tentacles would regain their original length immediately or almost immediately after the internal pressure and distension were again established. But the increase in length was gradual, although the tentacles were apparently fully distended about December 21. Moreover, they never regained their original length, the maximum being 70 per cent. of the original length.

These facts render it evident that an actual reduction in the length of the tentacles occurred during the period of reduced water-pressure. The failure of the tentacles to regain their original length is probably due to the loss of vigor observable in all specimens kept without food for a long period and the consequent diminution in internal water-pressure and in the power of growth. Regenerated tentacles never attain the length of the original tentacles and similarly those tentacles elongating after reduction never attain the original length.

In this experiment the process of reduction did not pass beyond the first stage. The tips of the tentacles did not shrivel, but remained healthy and became distended again after closure occurred, though the original length was never attained. It is possible that the frequent partial distension of the tentacles during the intervals between reopening of the aboral end was sufficient to prevent the death of the tissues. As was noted in a previous paper ('04*b*) the pieces must be reopened every few hours in order to prevent partial distension in the intervals, but this is impracticable for the long time necessary for perfect results. Consequently the method is by no means perfect.

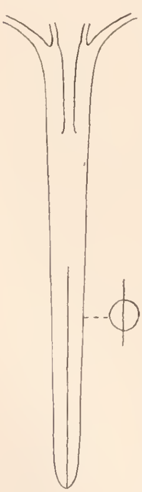

Fig. 7.

Series 19.

September 15, 1903.—In six large specimens the aboral half of the body was split by a longitudinal cut into two parts (Fig. 7).

The object of this experiment was not tentacle reduction but the duplication of the aboral end and consequently the lengths of the tentacles were not determined as frequently during the earlier stages as in experiments on tentacle-reduction. Later, however, when it was observed that these specimens would afford interesting evidence upon this point, measurements of the marginal tentacles were made regularly.

The split aboral portions of these specimens rolled in various ways and closure was greatly delayed, the delay being further increased by the frequent rupture of the delicate new tissue in consequence of contraction during the necessary examinations.

The length of the tentacles in the fully distended specimens before section was as follows: marginal tentacles 25–30 mm.; labial tentacles 12–13 mm.

After section the usual collapse occurred and the tentacles gradually decreased in length.

October 6. — 21 days after section. The pieces have remained almost completely collapsed since section. In some instances a part of the body which was more or less completely closed off became slightly distended, but, the frequent examination and removal of slime caused contraction and total collapse. The tentacles were not measured, but marked reduction had occurred during the period of collapse and at this time the tips of all the marginal tentacles were beginning to atrophy.

October 22. — 37 days after section. Two pieces were lost during the interval. The remaining four pieces were somewhat distended with water but any contraction caused loss of water either in consequence of rupture of new tissue or through one or both of the duplicated aboral pores about which the regenerating muscles had not fully developed. Consequently the internal pressure was still relatively very slight. Extensive atrophy of the distal portion of both marginal and labial tentacles had occurred. The marginal tentacles measured 6–7 mm. + 1–2 mm. of shrivelled tissue representing the distal portion of the tentacle. The labial tentacles measured 3–4 mm. + 1 mm. of shrivelled tissue. The basal healthy portions of the tentacles ended bluntly instead of in slender tips as in normal specimens: upon these blunt ends were borne the small shrivelled masses of tissue.

During the following month the pieces succeeded in closing sufficiently to permit considerable increase of internal pressure and no longer lost water during slight contractions.

December 1. — 77 days after section. In three of the pieces the marginal tentacles have increased in length to 10 mm. and the labial tentacles to about 5 mm.

In the fourth specimen the marginal tentacles were 7–8 mm. and the labial tentacles about as before.

In all the atrophied tips have almost completely disappeared, apparently having undergone resorption, but the tentacles are still blunt, not tapering like normal tentacles.

During the next twenty days the pieces showed a considerable reduction in size in consequence of decreasing internal pressure and the distal portions of the tentacles once more began to shrivel.

December 21. — 97 days after section. Marginal tentacles in all four pieces 3–4 mm. + 1–2 mm. of shrivelled tissue.

It was evident at this time that the pieces were becoming exhausted and the experiment was concluded.

In these pieces a gradual reduction in the length of the tentacles occurred during the first two weeks, then the tips began to atrophy, thus reducing the functional portion of the tentacle still further. When closure of the pieces permitted distension the tentacles elongated again and the atrophied tips underwent almost complete resorption. Still later, as the pieces became exhausted and the temperature of the water became lower, the tips of the tentacles once more began to shrivel and at the conclusion of the experiment mere stumps remained.

Reduction of the tentacles was also observed in *C. solitarius* in many œsophageal pieces, *i. e.*, pieces retaining the tentacles and with the aboral end in the œsophageal region (Fig. 8). In such pieces the œsophagus united with the body-wall aborally as in the pieces described in the preceding paper ('04*d*), and except in cases where closure of the body-wall across the end of the œsophagus occured, the internal pressure was never reëstablished.

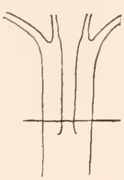

FIG. 8.

In one piece of this kind which closed aborally across the end of the œsophagus after eleven days the marginal tentacles decreased in length before closure from 25–30 mm. to 10–12 mm. and the labial tentacles from 10–12 mm. to 6–7 mm. After closure the length of the marginal tentacles increased again to about 20 mm. and that of the labial tentacles to about 10 mm. Here the period of collapse was comparatively short and there was no shrivelling of the tips of the tentacles. In another œsophageal piece the marginal tentacles decreased in three months from 35 mm. to mere stumps 3 mm. in length and the labial tentacles from 12 mm. to 1.5 mm. In this case, as in Series 19 above, the reduction of the tentacles consisted at first merely of a decrease in length, the tissues remaining normal in appearance except as regards the darker color due to the collapsed condition. Later shrivelling of the tips began and continued until only blunt rounded stumps bearing small masses of the dark, shrivelled tissue remained.

In *C. membranaceus* a similar reduction of tentacles was observed, both in pieces which were kept open by artificial means and in œsophageal pieces, but in no case did the distal portions shrivel as in *C. solitarius*. This difference in behavior is probably due to the firmer consistency of the tissues of *C. membranaceus*. In one piece which was opened every day during forty-nine days the marginal tentacles decreased from 40–50 mm. to 10–15 mm. and the labial tentacles from 20 mm. to 3–4 mm. This piece was then allowed to close and become distended and during the next thirty-nine days the marginal tentacles increased in length to 20 mm. and the labial tentacles to 5 mm. In this case the decrease in length was nearly 75 per cent. for the marginal tentacles and about 80 per cent. for the labial tentacles. The marginal tentacles after renewed distension attained nearly 50 per cent. of the original length, the labial tentacles only 25 per cent.

The œsophageal pieces of *C. membranaceus* were not observed to close aborally across the end of the œsophagus in any case. It was therefore impossible to observe increase in length of the tentacles after reduction in these pieces, but marked reduction was observed in all cases. In one piece the marginal tentacles decreased during twenty-seven days from 60 mm. to 20–25 mm. and the labial tentacles from 25 mm. to 10–12 mm. and in others a similar reduction was noted.

It is possible that atrophy of the tips of the tentacles would have occurred if the specimens had been kept for a still longer time. On the other hand this process may be so slow in this species that it is visible merely as a gradual reduction in size.

In view of these facts there can be little doubt that the length of the tentacles is influenced by the internal pressure. The question as to whether it is the general internal pressure which exerts this influence, the effect being merely more conspicuous in the tentacles than elsewhere, or whether local pressure due to currents plays a part must be decided by future experiments.

Various other facts noted in the course of my experiments require mention here. It was noted that regenerating tentacles attained a greater length during the summer months than during winter (*cf.* Child, '03*b*). This difference is probably due, at least in part, to the fact that the internal pressure is higher in summer than in winter in consequence of the greater activity of the cilia in forcing water in through the œsophagus (*cf.* Child, '04*b*). Local pressure must also vary in a similar manner.

It was also observed in a large number of cases that the tentacles of normal animals or regenerated specimens of *C. solitarius* often began to shrivel at the tips in the manner described above when the specimens had been kept in captivity and without special feeding for two months or more. Frequently the marginal tentacles were reduced to a length of 5–6 mm., the specimens appearing otherwise healthy and in good condition, except that the body was in all cases less distended than in newly taken specimens. In the light of the preceding experiments the conclusion is justifiable that the tentacle-reduction in these species is due to decrease in internal water-pressure. The gradual exhaustion of the pieces and the consequent diminution of ciliary activity is without doubt one factor in the result.

As winter approached it was noted that the atrophy of the tentacles began sooner and proceeded farther. During December many of the specimens brought into the laboratory from the bay possessed marginal tentacles only 8–10 mm. in length with atrophied tips and labial tentacles similarly reduced. In nearly all specimens with the tentacles normal in appearance at the time of taking, the atrophy of the tips began within a week or two.

In January and the early part of February, beyond which time my observations do not extend, more than a hundred specimens were taken and of these about 75 per cent. possessed reduced tentacles with atrophied tips when taken. Many of the remainder were specimens with regenerating tentacles, which had undoubtedly been injured.

During the summer and autumn reduced tentacles with atrophied tips were not found on any specimen at the time of taking. Moreover, the tentacles of summer and autumn specimens were always much longer than those of winter specimens even when the latter were not atrophied.

These facts leave no room for doubt that the reduction of the tentacles and the loss of their tips is a normal phenomenon during the winter months. I was able, however, to bring about this change experimentally in September and October, *i. e.*, at a time when newly taken specimens showed no trace of such a change.

Unfortunately it was impossible to continue observations during the spring. I have no doubt, however, that as the temperature of the water rose the internal pressure became greater and the tentacles increased in length again.

The animals do not thrive in aquaria with standing water and it was not practicable to supply the aquaria with running water kept at a constant temperature approaching that of the water in summer. For these reasons the experiment of keeping the animals with reduced tentacles in water of a higher temperature than that in which they had been living could not be carried out satisfactorily. I venture to predict, however, that the result of such an experiment would be an elongation of the reduced tentacles, though probably they would never attain the full summer length unless the animals were well fed.

There is no ground for supposing that the specimens with atrophied tentacles were in a pathological condition. Specimens which were in this condition when taken lived for months in captivity and regenerated as completely as other specimens. After atrophy of a certain portion of a tentacle the atrophied portion was gradually absorbed and the remaining proximal portion retained a perfectly healthy appearance until the gradual decrease in internal pressure due to exhaustion brought about a further atrophy. These reduced tentacles could be distinguished at once from normal tentacles by their blunt tips.

The only conclusion possible in view of the facts appears to me to be that any condition which reduces the internal water-pressure to a sufficient extent will bring about the atrophy of the tentacles. Experimentally reduction of pressure was accomplished by preventing closure, but it is clear that any condition which decreases ciliary activity will decrease the internal pressure, since the force of the inward current through the œsophagus is reduced. The force of circulatory currents in the body must be similary reduced and consequently any local pressure due to them is also reduced.

Decrease in temperature is a condition which reduces ciliary activity. It follows that in winter specimens the cilia must be much less active than in summer specimens. Winter specimens are visibly less distended than summer specimens. I can see no escape from the conclusion that the atrophy of the tentacles in winter specimens is due as in experimental pieces to a long-continued reduction to a relatively low level of the internal water-pressure, resulting in this case from the reduction of ciliary activity in consequence of low temperature.

The fact that the shrivelling of the tentacle always begins at the tip and proceeds gradually in the proximal direction is of some importance. If this process is the result of decrease in the general internal pressure why should the reduction proceed from the tip? According to the laws of hydrostatics the internal pressure must be the same in all parts of the enteric cavity, consequently when reduction of the pressure occurs it occurs at all points. This being the case why should a slight reduction of pressure affect merely the tip of the tentacle, while a greater reduction causes atrophy of a larger part?

In the present state of our knowledge two explanations of this fact appear possible. It may be that the distal portions of the tentacle exist under relatively unfavorable conditions of nutrition as compared with the proximal portions. The small size of the tentacular cavity in this region and the consequent imperfect circulation of fluid and also its distance from the central cavity where most of the digestion probably occurs, afford a possible basis for such an assumption. If the stimulus of internal pressure is effective upon the tissues of *Cerianthus* we should expect to find the poorly nourished parts of the body more sensitive than other portions to decrease in this stimulus. According to this view reduction of internal pressure might result in atrophy beginning at the tips of the tentacles and proceeding proximally according to the degree and duration of the reduction.

The second explanation is based upon the possible effect of local pressure due to circulatory currents. It is evident that with approach toward the distal end of the tentacle the circulatory currents must decrease in force and volume since in the confined space of the tentacular cavity the friction between the currents in opposite directions is relatively greater than in the enteron. The force and volume of the currents must also depend upon the degree of distension of the tentacle and body and therefore upon the general internal pressure. If, therefore, the internal pressure be reduced, the tentacular cavity decreases in size, and the circulatory currents are practically eliminated in the extreme distal portion of the tentacles: local pressure at the tip of the tentacle is thus reduced. It is possible that this is a factor in bringing about a condition of malnutrition. According to this view the atrophy of the distal portion may be the result of the reduction of local pressure in the distal portion of the tentacle in consequence of the reduction in force and volume of the circulatory current. The larger, proximal portion is still of sufficient size even under reduced pressure to permit the existence of these currents.

Since I have mentioned in previous papers certain facts which seem to indicate the possibility that local pressure due to circulatory currents may constitute a formative factor in *Cerianthus* the possible effect of these currents is mentioned in this connection. It is possible that both reduction in local pressure and malnutrition of the distal portions of the tentacles may coöperate in causing atrophy under reduced general pressure. But whatever interpretation may be placed upon the facts, the occurrence of atrophy under reduced internal pressure is clearly shown.

Summary.

1. Pieces of *C. membranaceus* in which the enteron remains widely open to the exterior may show some degree of tentacle-regeneration. In such pieces the inrolling of the oral margin and the pressure of the cut surface against the mesenteries may be sufficient to prevent the escape of water and thus permit the establishment of some degree of internal pressure within the in-

rolled portion. In all cases of this kind tentacle-regeneration is much delayed and never proceeds far.

2. It is possible by reduction of the internal water-pressure to cause reduction of fully grown normal tentacles in both *C. solitarius* and *C. membranaceus.* The first stage in the reduction consists in a gradual decrease in length and size of the tentacles: in *C. membranaceus* no further change was observed, but in *C. solitarius* shrivelling and atrophy of the tentacles began at the tips if the reduced pressure continued. In specimens which were kept widely open the tentacles were reduced to mere stumps a few millimeters in length.

3. If specimens with partially atrophied tentacles be allowed to close, the basal healthy portion of the tentacle begins to extend as the internal pressure is reëstablished.

4. Atrophy of the distal portion of the tentacles occurs in specimens of *C. solitarius* which are kept for a long time without food and is also found in nearly all specimens taken during the midwinter season.

5. Since the internal pressure in normal animals is due primarily to the activity of cilia any conditions which reduce the activity of the cilia reduce the pressure. Low temperature and starvation or exhaustion cause reduction in ciliary activity and so in internal pressure. If these conditions continue for a certain length of time atrophy begins at the tips of the tentacles, proceeding proximally as the reduction in pressure continues.

6. The fact that atrophy due to reduced pressure always begins at the tip of the tentacle may be explained by the relatively greater reduction in the force and volume of the circulatory currents in the distal region in consequence of the smaller size of the tentacular cavity in that region or it may be due to a condition of malnutrition in the distal regions of the tentacles which in turn is the result of the small size of the tentacular cavity and the distance from the main digestive cavity. In this condition the distal regions of the tentacle are less capable of continuing their existence under unfavorable conditions (*e. g.*, reduced pressure) than the more proximal portions. Possibly both of these factors are concerned in the result.

Hull Zoölogical Laboratory,
University of Chicago, November, 1903.

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